APPENDIX

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Chris Rauwendaal

Polymer Extrusion

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Polymer Extrusion

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Plug flow generally does not happen in polymer melts, except in the case of wall slip (PVC). However, it does occur with granular polymeric solids. The solids conveying theory of single screw extruders is based on the assumption of plug flow of the solid polymer.

SHEAR RATE ($\dot{\gamma}$): The difference in velocity per unit normal distance (normal to the direction of flow).

The rate of shearing or shear rate is one of the most important parameters in polymer melt processing. If the process is to be described quantitively, the shear rate in the fluid at any location needs to be known. The shear rate is generally written with the Greek letter gamma, $\dot{\gamma}$, with the dot above the gamma indicating a time derivative $\left(\dot{\gamma} = \frac{d\gamma}{dt}\right)$. In terms of Figure 6–8, the shear rate can be written as:

$$\dot{\gamma}_{AB} \approx \frac{v_A - v_B}{AB} \qquad (6\text{–}10)$$

Equation 6-10 is only valid for very small values of the normal distance AB. More accurately, the shear rate is:

$$\dot{\gamma}_{AB} = \lim_{AB \to 0} \frac{v_A - v_B}{AB} = \frac{dv(x)}{dy} \qquad (6\text{–}11)$$

From equation 6–11, it can be seen that the local shear rate equals the local gradient of the velocity profile. Thus, if the velocity profile is known, the shear rate at any location can be determined.

SHEAR STRAIN (γ): Displacement (in the direction of flow) per unit normal distance over a certain time period.

The shear strain is generally written with the Greek letter gamma (γ), this time without the dot! The relationship between shear rate ($\dot{\gamma}$) and shear strain (γ) is:

$$\dot{\gamma} = \frac{d\gamma}{dt} \quad \text{and} \quad \gamma = \int \dot{\gamma}\, dt \qquad (6\text{–}12)$$

In terms of Figure 6–8, the shear strain can be written as:

$$\gamma_{AB} \approx \frac{x_A - x_B}{AB} = \frac{\Delta x}{\Delta y}\bigg|_{AB} = \tan\beta \qquad (6\text{–}13)$$

The units of shear rate are $\sec^{-1}$ and the shear strain is a dimensionless number.

SHEAR STRESS (τ): The stress required to achieve a shearing type of deformation.

When a fluid is sheared, a certain force will be required to bring about that deformation. This force divided by the area over which it works is the shear stress. The shear stress is generally written with the Greek letter tau (τ). In a simple example, shown in Figure 6–10, the shear stress is:

Figure 6-10. Simple Shear Def

$$\tau = \frac{F}{A}$$

and the shear rate is:

$$\dot{\gamma} = \frac{v}{\Delta y}$$

SHEAR VISCOSITY (η):

$$\eta = \frac{\tau}{\dot{\gamma}}$$

The shear viscosity is gener
stress x time. The viscosity
Poise). In order to determi
rate in a certain shear defo
are available to determine
ters.

NEWTONIAN FLUID: A

Most low viscosity liquids
versus shear rate, a Newto
b. Therefore, Newtonian f

A plot of shear stress vers

NON-NEWTONIAN FL

High viscosity polymer m
with increasing shear rate

Another type of non-Nev
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Figure 6-11. Flow Curves c
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